Remote Sensing High Data Rate End-to-End System Architecture Trades

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Abstract

The Jet Propulsion Laboratory and Goddard Space Flight Center performed a study from July to November 1998 to assess the characteristics of future high data rates of earth observing science instruments and assess the technical feasibility and technology development required of processing systems and communications technologies to meet those data rates.

This paper contains three major advanced technologies to resolve critical science issues. We discuss the instrument data rates needed to support the future high spectral and spatial resolution hyperspectral imaging instruments, the lidar and the synthetic aperture radar. These rates are projected out from the year 2000 to 2006 based on the expectation of a demand for more capable instruments with higher spatial and spectral resolution. We discuss onboard processing of data and intelligent data extraction at the instrument level. In this approach, significantly interesting data are extracted and processed onboard the satellite at the instrument level to reduce the requirement for onboard data storage and to take advantage of the high-data-rate transmission. We describe data reduction rates on the orders of 10, 100, and 1000 and discuss the required processing speeds, electrical power requirements, and general feasibility of meeting these target rates by the specified dates. The intelligent data extraction approach was deliberately selected to be aggressive since it had the potential of providing the greatest relief to the onboard storage and downlink telecommunications requirements. We evaluate DRAM and disk-drive onboard data storage options that would support the instrument data rates and onboard processing. Additionally, we describe data compression of imaging data that will facilitate the recovery of higher data volumes using lower telecommunications data rates

We describe the general telecommunications architecture. We describe the X-band, Ka-band, and optical telecommunications spacecraft transceivers for the 0.1, 1, and 10 Gbps telecommunications data rates. We present the configuration of the optical ground station for the high-data-rate reception, and explore the data-distribution approaches that are expected to be available to stations located within the continental United States (CONUS). We did not include details of the modifications to the RF ground stations to support these high data rates in this study. However, we do identify Svalbard, Norway, and the SAR facility in Alaska, two high-latitude stations that give visibility to the spacecraft on almost every pass, thus reducing the required onboard storage when these ground receiver sites are used.

We describe a LEO-to-GEO and GEO-to-ground-relay optical. In this scenario, three ground stations located in the southwestern United States would provide 97% weather availability. Three stations located strategically in CONUS would support most of the mission requirements. This approach eliminates the need for a global network of ground stations.

We also, describe strategies for high-speed data storage and distribution from the ground stations. We present the mass and power consumption for the spacecraft telecommunications system along with the estimated costs for the spacecraft RF and optical communications terminals. Finally, we present our conclusions and recommendations for future work.